A Preferred Service Architecture for Payload Data Flows

Ray Gilstrap, Thom Stone, Ken Freeman

NASA Research and Engineering Network
NASA Advanced Supercomputing Division
NASA Ames Research Center

Outline

- Best Effort Service Overview
- Application Requirements
- Quality of Service Mechanisms
- Quality of Service Architectures
- Conclusion - Mission Benefits
- Next Steps

Best Effort Service

- Traditional Internet architecture is "Best Effort"
  - The network puts forth its best effort to forward packets to their destinations in order and without loss
  - All packets are treated the same by the network, regardless of source, destination, or content
- Sometimes best effort isn't good enough
  - Packets may be dropped due to link congestion, lack of space in the router queue, node or link failures
  - Packets originally transmitted as a steady stream may be received as bursts of packets with irregular arrival times
  - No distinction between "more important" and "less important" traffic
- Different ways developed to cope with these problems
  - TCP takes care of reliability and in-order delivery for a given flow, but at a cost of timeliness
  - Virtual circuit service addresses the link congestion problem, but bandwidth earmarked for a given flow can be wasted if that flow is not using its full allocation

Application Requirements

- Voice
  - May be a live or pre-recorded stream, one-way or bidirectional
  - One-way voice is tolerant of high latency, but intolerant of high jitter
  - Live, two-way voice is less tolerant of high latency (e.g., no real-time phone calls to Mars)
  - Some packet loss is acceptable if it reduces overall jitter
  - Must receive at least a (codec-dependent) minimum amount of bandwidth

- Video
  - Similar characteristics to voice, except video can be more intolerant of packet loss
  - Also higher bandwidth requirements

Application Requirements

- Bulk file transfer
  - Generally tolerant of high latency and jitter, but intolerant of packet loss.
  - Generally high bandwidth requirements

- Instrument command and control
  - Generally lower bandwidth requirements than video and (possibly) voice, but intolerant of packet loss or out-of-order delivery
  - May also have tight latency requirements, but more tolerant of jitter

Quality of Service

- Traffic from all of these applications is multiplexed over a shared set of links

- Solution to provide each application with its required service – Quality of Service (QoS)
  - Allows different types of traffic to receive unequal treatment on the network

- Most often implemented at the network layer, although link-layer QoS is also common

QoS Mechanisms

- ## Classification
  - Segregating traffic into different classes, which will receive different treatment
  - Traffic can be classified according to fields in the TCP/IP headers
    - Source/Destination IP, port, protocol
    - IP TOS byte

- ## Queuing
  - Implementing a queue for each traffic class
  - Parameters: number of queues, queue size, discard policy (e.g., drop-tail, random early detection, etc)

- ## Scheduling
  - Servicing the set of queues according to some priority scheme
  - Common choices: weighted fair queuing, weighted round-robin

QoS Mechanisms

- Shaping
  - "Smoothing out" burstiness in incoming traffic
  - Common mechanisms - leaky bucket, token bucket
- Marking
  - Identifying traffic that does/does not conform to a specified traffic profile
  - Downstream elements may choose to allow or discard marked traffic
- Policing
  - Discarding packets that do not conform to the traffic profile
  - No further questions…

QoS Architectures

- Integrated Services (IntServ)
  - Provides End-to-end QoS control
  - Applications request to reserve resources form the network, and each router along the path between source and destination signal whether the reservation can be supported
  - Operates on a per-flow basis
  - ReSerVation Protocol (RSVP) - Reservation signaling and negotiation protocol
    - PATH messages from sender to receiver say what the sender wants
    - RESV messages from receiver to sender say what the sender can get
  - Drawbacks
    - Complexity of architecture
    - Each router must keep per-flow state
    - Requires symmetric links

QoS Architectures

- Differentiated Services (DiffServ)
  - Traffic is classified into groups labeled with given DiffServ codepoints (DSCPs), indicated in the IP TOS byte
  - Each DSCP specifies a particular per-hop behavior (PHB) to be experienced by the associated traffic
  - PHBs can specify queue management mechanisms, service policies
  - Common PHBs:
    - Expedited Forwarding (EF) - Packets must be serviced at least as fast as they arrive
    - Assured Forwarding (AF) - Less stringent, specifies queue management and drop precedence
  - Advantages:
    - Simplified architecture
    - Routers need only maintain configuration state about each PHB, instead of each flow

QoS Architectures

- Multi-Protocol Label Switching (MPLS)
  - Generalization of the Virtual Circuit model - Construct fixed paths through the routing infrastructure
  - Allows arbitrary paths to be constructed to better share load over links
  - MPLS paths need not be the shortest path
  - IP packets are encapsulated in MPLS frames, which indicate the Label-switched path (LSP) that the frame should follow

Putting Everything Together

- Space-based networks will include multiple IP routing nodes connected via RF links
- Can implement QoS features at each (on-board) router
- DiffServ offers simplicity
- Can use MPLS to drive some traffic (e.g., file transfers) traffic to longer but higher-bandwidth paths
- Payload data can be labeled on ingress to router, then scheduled for transmission on the outgoing link
- Different PHBs for voice, video, command and control, and file transfers

Mission Benefits

- Multiple classes of traffic can receive the service they require over a unified network
- Protects mission-critical traffic from being starved of network resources by non-critical traffic
- Scalable architecture
  - Multiple on-board data sources may receive preferential treatment from an on-board router
  - Data from multiple missions may receive preferential treatment by routers in a common backbone infrastructure using the same mechanisms

Next Steps

- Empirical study - Implementation of basic QoS architecture in laboratory emulated space environment
  - Linux QoS routers atop SDR-based RF links
- Characterization of application performance under various QoS configurations to determine optimal parameters

Next Steps